CLAIMS

WE CLAIM:

1. An electromagnetic beam chromatic shifting and directing means for use in reflectively directing a spectroscopic beam of electromagnetic radiation while de-emphasizing intensity in visual wavelengths and while simultaneously increasing both IR and UV wavelength intensities, said electromagnetic beam chromatic shifting and directing means comprising a silicon substrate with between 500 and 1500 Angstroms of silicon dioxide substantially uniformly present on a reflective surface thereof.

2. A method of providing a spectroscopic beam of electromagnetic radiation with more energy in IR and UV wavelength ranges than is present in a source of spectroscopic electromagnetic radiation comprising the steps of:

a) providing a source of spectroscopic electromagnetic radiation;

b) providing electromagnetic beam chromatic shifting and directing means for use in reflectively directing a spectroscopic beam of electromagnetic radiation while de-emphasizing intensity in visual wavelengths while simultaneously increasing both IR and UV wavelength intensities;

c) causing said source of spectroscopic electromagnetic radiation to provide a beam thereof and directing it to impinge upon said electromagnetic beam chromatic shifting and directing means at an oblique angle such that a reflected beam of electromagnetic radiation is produced, said reflected beam of electromagnetic radiation having decreased energy in visual

wavelengths and increased energy in IR and UV wavelengths.

3. An ellipsometer system comprising:

a source of electromagnetic radiation (ZQTH);

input means (ZINPUT) comprising:

optical fiber (ZOF);
coupler (ZSMA);
colimating lens (ZCL);
beam directing mirror (ZM) or beam chromatic shifting and directing means (ZCM);
polarizer (ZP1);
first rotatable compensator (ZC1);

sample supporting stage;

output means (ZOUTPUT) comprising:

second rotatable compensator (ZC2);
analyzer (ZP2);
beam directing mirror (ZM) or beam chromatic shifting and directing means (ZCM);
focusing lens (ZFL);
spectrometer (ZSPEC);

such that in operation the Source of electromagnetic radiation (ZQTH) provides spectroscopic electromagnetic radiation to one end of said optical fiber (ZOF), a second end thereof being secured in coupler (ZSMA), and a beam of electromagnetic energy exiting said coupler (ZSMA) is collimated by colimating lens (ZCL) and directed toward beam directing mirror (ZM) or beam chromatic shifting and directing means (ZCM), from which it

reflects, said reflected beam being caused to pass through polarizer (ZP1) and the first rotatable compensator (ZC1) before being caused to impinge upon a sample (ZS) which is held in position by said sample supporting stage, electromagnetic radiation which reflects from said sample (ZS) being directed to pass through second rotatable compensator (ZC2) and said analyzer (ZP2) before being caused to reflect from a beam chromatic shifting and directing means (ZCM) or beam directing mirror (ZM), said electromagnetic radiation reflected from said beam chromatic shifting and directing means (ZCM) being then caused to pass through focusing lens (ZFL) and enter spectrometer (ZSPEC) which comprises a multi-element detector system;

there being at least one beam chromatic shifting and directing means (ZCM) present between said source of electromagnetic radiation (ZQTH) and said spectrometer (ZSPEC), which de-emphasizes intensity in visual wavelengths and while simultaneously increasing both IR and UV wavelength intensities.

4. A method of investigating a sample (ZS) comprising the steps of:

a) providing an ellipsometer system comprising:

a source of electromagnetic radiation (ZQTH);

input means comprising:

optical fiber (ZOF);
coupler (ZSMA);
colimating lens (ZCL);
beam directing mirror (ZM) or beam chromatic shifting and directing means (ZCM);
polarizer (ZP1);

first rotatable compensator (ZC1);

sample supporting stage;

output means comprising:

second rotatable compensator (ZC2);
analyzer (ZP2);
beam directing mirror (ZM) or beam chromatic shifting and directing means (ZCM);
focusing lens (ZFL);
spectrometer (ZSPEC);

such that in operation the source of electromagnetic radiation (ZQTH) provides spectroscopic electromagnetic radiation to one end of said optical fiber (ZOF), a second end thereof being secured in coupler (ZSMA), and a beam of electromagnetic energy exiting said coupler (ZSMA) is collimated by colimating lens (ZCL) and directed toward beam directing mirror (ZM) or beam chromatic shifting and directing means (ZCM), from which it reflects, said reflected beam being caused to pass through polarizer (ZP1) and the first rotatable compensator (ZC1) before being caused to impinge upon a sample (ZS) which is held in position by said sample supporting stage, electromagnetic radiation which reflects from said sample (ZS) being directed to pass through second rotatable compensator (ZC2) and said analyzer (ZP2) before being caused to reflect from a beam chromatic shifting and directing means (ZCM) or beam directing mirror (ZM), said electromagnetic radiation reflected from said beam chromatic shifting and directing means (ZCM) being then caused to pass through focusing lens (ZFL) and enter spectrometer (ZSPEC) which comprises a multi-element detector system;

there being at least one beam chromatic shifting and directing

means (ZCM) present between said source of electromagnetic radiation (ZQTH) and said spectrometer (ZSPEC), which de-emphasizes intensity in visual wavelengths and while simultaneously increasing both IR and UV wavelength intensities;

b) while causing said source of electromagnetic radiation (ZQTH) to provide a beam of spectroscopic electromagnetic radiation, interact with said sample (ZS) and enter said spectrometer (ZSPEC), causing at least one element selected from the group consisting of:

polarizer (ZP1);
analyzer (ZP2);
first rotatable compensator (ZC1);
second rotatable compensator (ZC2);

to be continusously rotated or be sequentially stepped through a progression of discrete polarization state setting positions.

5. A spectroscopic ellipsometer system comprising:

a source of polychromatic electromagnetic radiation;
a polarizer which is fixed in position during data acquisition;
a stage for supporting a sample system;
an analyzer which is fixed in position during data acquisition; and
a multi-element spectroscopic detector system;

said spectroscopic ellipsometer system further comprising at least one means for discretely, sequentially, modifying a polarization state of a beam of electromagnetic radiation provided by said source of polychromatic electromagnetic radiation through a plurality of polarization states, said means

for discretely, sequentially, modifying a polarization state of a beam of electromagnetic radiation provided by said source of polychromatic electromagnetic radiation through a plurality of polarization state being present at at least one location selected from the group consisting of:

between said polarizer and said stage for supporting a sample system; and

between said stage for supporting a sample system and said analyzer;

and positioned so that said beam of electromagnetic radiation transmits therethrough in use;

in which said at least one means for discretely, sequentially, modifying a polarization state of a beam of electromagnetic radiation provided by said source of polychromatic electromagnetic radiation through a plurality of polarization states, involves at least one rotatable compensator that changes the phase angle between orthogonal components of said electromagnetic beam of radiation provided by said source of polychromatic electromagnetic radiation;

said spectroscopic ellipsometer system being characterized by having, in a path of the electromagnetic beam between said a source of polychromatic electromagnetic radiation and said multi-element spectroscopic detector system, at least one beam chromatic shifting and directing means for use in reflectively directing a spectroscopic beam of electromagnetic radiation while de-emphasising visual wavelength intensity and simultaneously emphasising IR and UV wavelength intensities.

6. A spectroscopic ellipsometer system as in Claim 5, in which

the rotatable compensator comprises a single element.

7. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises at least two per se. zero-order waveplates (MOA) and (MOB), said per se. zero-order waveplates (MOA) and (MOB) having their respective fast axes rotated to a position offset from zero or ninety degrees with respect to one another, with a nominal value being forty-five degrees.

8. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises a combination of at least a first (ZO1) and a second (ZO2) effective zero-order wave plate, said first (ZO1) effective zero-order wave plate being comprised of two multiple order waveplates (MOA1) and (MOB1) which are combined with the fast axes thereof oriented at a nominal ninety degrees to one another, and said second (ZO2) effective zero-order wave plate being comprised of two multiple order waveplates (MOA2) and (MOB2) which are combined with the fast axes thereof oriented at a nominal ninety degrees to one another; the fast axes (FAA2) and (FAB2) of the multiple order waveplates (MOA2) and (MOB2) in said second effective zero-order wave plate (ZO2) being rotated to a position at a nominal forty-five degrees to the fast axes (FAA1) and (FAB1), respectively, of the multiple order waveplates (MOA1) and (MOB1) in said first effective zero-order waveplate (ZO1).

9. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises at least a first (ZO1) and a second (ZO2) effective zero-order wave plate, said first (ZO1) effective zero-order wave plate being comprised of two multiple order waveplates (MOA1) and (MOB1) which are combined with the fast axes thereof oriented at a nominal ninety degrees to one another, and said second (ZO2) effective zero-order wave plate

being comprised of two multiple order waveplates (MOA2) and (MOB2) which are combined with the fast axes thereof oriented at a nominal ninety degrees to one another; the fast axes (FAA2) and (FAB2) of the multiple order waveplates (MOA2) and (MOB2) in said second effective zero-order wave plate (ZO2) being rotated to a position away from zero or ninety degrees with respect to the fast axes (FAA1) and (FAB1), respectively, of the multiple order waveplates (MOA1) and (MOB1) in said first effective zero-order waveplate (ZO1).

10. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises at least one zero-order waveplate, ((MOA) or (MOB)), and at least one effective zero-order waveplate, ((ZO2) or (ZO1) respectively), said effective zero-order wave plate, ((ZO2) or (ZO1)), being comprised of two multiple order waveplates which are combined with the fast axes thereof oriented at a nominal ninety degrees to one another, the fast axes of the multiple order waveplates in said effective zero-order wave plate, ((ZO2) or (ZO1)), being rotated to a position away from zero or ninety degrees with respect to the fast axis of the zero-order waveplate, ((MOA) or (MOB)).

11. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises a first triangular shaped element, which as viewed in side elevation presents with first and second sides which project to the left and right and downward from an upper point, which first triangular shaped element first and second sides have reflective outer surfaces; said retarder system further comprising a second triangular shaped element which as viewed in side elevation presents with first and second sides which project to the left and right and downward from an upper point, said second triangular shaped element being made of material which provides reflective interfaces on first and second

sides inside thereof; said second triangular shaped element being oriented with respect to the first triangular shaped element such that the upper point of said second triangular shaped element is oriented essentially vertically directly above the upper point of said first triangular shaped element; such that in use an input electromagnetic beam of radiation caused to approach one of said first and second sides of said first triangular shaped element along an essentially horizontally oriented locus, is caused to externally reflect from an outer surface thereof and travel along a locus which is essentially upwardly vertically oriented, then enter said second triangular shaped element and essentially totally internally reflect from one of said first and second sides thereof, then proceed along an essentially horizontal locus and essentially totally internally reflect from the other of said first and second sides and proceed along an essentially downward vertically oriented locus, then externally reflect from the other of said first and second sides of said first triangular shaped elements and proceed along an essentially horizontally oriented locus which is undeviated and undisplaced from the essentially horizontally oriented locus of said input beam of essentially horizontally oriented electromagnetic radiation; with a result being that retardation is entered between orthogonal components of said input electromagnetic beam of radiation.

12. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises, as viewed in upright side elevation, first and second orientation adjustable mirrored elements which each have reflective surfaces; said compensator system further comprising a third element which, as viewed in upright side elevation, presents with first and second sides which project to the left and right and downward from an upper point, said third element being made of material which provides reflective interfaces on first and second sides inside thereof; said third element being oriented with respect to said first and

second orientation adjustable mirrored elements such that in use an input electromagnetic beam of radiation caused to approach one of said first and second orientation adjustable mirrored elements along an essentially horizontally oriented locus, is caused to externally reflect therefrom and travel along a locus which is essentially upwardly vertically oriented, then enter said third element and essentially totally internally reflect from one of said first and second sides thereof, then proceed along an essentially horizontal locus and essentially totally internally reflect from the other of said first and second sides and proceed along an essentially downward vertically oriented locus, then reflect from the other of said first and second orientation adjustable mirrored elements and proceed along an essentially horizontally oriented propagation direction locus which is essentially undeviated and undisplaced from the essentially horizontally oriented propagation direction locus of said input beam of essentially horizontally oriented electromagnetic radiation; with a result being that retardation is entered between orthogonal components of said input electromagnetic beam of radiation.

13. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises a parallelogram shaped element which, as viewed in side elevation, has top and bottom sides parallel to one another, both said top and bottom sides being oriented essentially horizontally, said retarder system also having right and left sides parallel to one another, both said right and left sides being oriented at an angle to horizontal, said retarder being made of a material with an index of refraction greater than that of a surrounding ambient; such that in use an input beam of electromagnetic radiation caused to enter a side of said retarder selected from the group consisting of:

right and left;

along an essentially horizontally oriented locus, is caused to diffracted inside said retarder system and follow a locus which causes it to essentially totally internally reflect from internal interfaces of both said top and bottom sides, and emerge from said retarder system from a side selected from the group consisting of

left and right respectively;

along an essentially horizontally oriented locus which is undeviated and undisplaced from the essentially horizontally oriented locus of said input beam of essentially horizontally oriented electromagnetic radiation; with a result being that retardation is entered between orthogonal components of said input electromagnetic beam of radiation.

14. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises first and second triangular shaped elements, said first triangular shaped element, as viewed in side elevation, presenting with first and second sides which project to the left and right and downward from an upper point, said first triangular shaped element further comprising a third side which is oriented essentially horizontally and which is continuous with, and present below said first and second sides; and said second triangular shaped element, as viewed in side elevation, presenting with first and second sides which project to the left and right and upward from an upper point, said second triangular shaped element further comprising a third side which is oriented essentially horizontally and which is continuous with, and present above said first and second sides; said first and second triangular shaped elements being positioned so that a

rightmost side of one of said first and second triangular shaped elements is in contact with a leftmost side of the oth r of said first and second triangular shaped elements over at least a portion of the lengths thereof; said first and second triangular shaped elements each being made of material with an index of refraction greater than that of a surrounding ambient; such that in use an input beam of electromagnetic radiation caused to enter a side of a triangular shaped element selected from the group consisting of:

first and second;

not in contact with said other triangular shape element, is caused to diffracted inside said retarder and follow a locus which causes it to essentially totally internally reflect from internal interfaces of said third sides of each of said first and second triangular shaped elements, and emerge from a side of said triangular shaped element selected from the group consisting of:

second and first;

not in contact with said other triangular shape element, along an essentially horizontally oriented locus which is undeviated and undisplaced from the essentially horizontally oriented locus of said input beam of essentially horizontally oriented electromagnetic radiation; with a result being that retardation is entered between orthogonal components of said input electromagnetic beam of radiation.

15. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises a triangular shaped element, which as viewed in side elevation presents with first and second sides which project to the left and right and downward from an upper point, said retarder system further comprising a third side

which is oriented essentially horizontally and which is continuous with, and present below said first and second sides; said retarder system being made of a material with an index of refraction greater than that of a surrounding ambient; such that in use a an input beam of electromagnetic radiation caused to enter a side of said retarder system selected from the group consisting of:

first and second;

along an essentially horizontally oriented locus, is caused to diffracted inside said retarder system and follow a locus which causes it to essentially totally internally reflect from internal interface of said third sides, and emerge from said retarder from a side selected from the group consisting of

second and first respectively;

along an essentially horizontally oriented locus which is undeviated and undisplaced from the essentially horizontally oriented locus of said input beam of essentially horizontally oriented electromagnetic radiation; with a result being that retardation is entered between orthogonal components of said input electromagnetic beam of radiation.

16. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises first and second Berek-type retarders which each have an optical axes essentially perpendicular to a surface thereof, each of which first and second Berek-type retarders has a fast axis, said fast axes in said first and second Berek-type retarders being oriented in an orientation selected from the group consisting of:

parallel to one another; and

other than parallel to one another;

said first and second Berek-type retarders each presenting with first and second essentially parallel sides, and said first and second Berek-type retarders being oriented, as viewed in side elevation, with first and second sides of one Berek-type retarder being oriented other than parallel to first and second sides of the other Berek-type retarder; such that in use an incident beam of electromagnetic radiation is caused to impinge upon one of said first and second Berek-type retarders on one side thereof, partially transmit therethrough then impinge upon the second Berek-type retarder, on one side thereof, and partially transmit therethrough such that a polarized beam of electromagnetic radiation passing through both of said first and second Berek-type retarders emerges from the second thereof in a polarized state with a phase angle between orthogonal components therein which is different than that in the incident beam of electromagnetic radiation, and in a propagation direction which is essentially undeviated and undisplaced from the incident beam of electromagnetic radiation; with a result being that retardation is entered between orthogonal components of said input electromagnetic beam of radiation.

17. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises first and second Berek-type retarders which each have an optical axes essentially perpendicular to a surface thereof, each of which first and second Berek-type retarders has a fast axis, said fast axes in said first and second Berek-type retarders being oriented other than parallel to one another; said first and second Berek-type retarders each presenting with first and second essentially parallel sides, and said first and second Berek-type retarders being oriented, as viewed in side elevation, with first and second sides of one Berek-type retarder being oriented other than

parallel to first and second sides of the other Berek-type retarder; such that in use an incident beam of electromagnetic radiation is caused to impinge upon one of said first and second Berek-type retarders on one side thereof, partially transmit therethrough then impinge upon the second Berek-type retarder, on one side thereof, and partially transmit therethrough such that a polarized beam of electromagnetic radiation passing through both of said first and second Berek-type retarders emerges from the second thereof in a polarized state with a phase angle between orthogonal components therein which is different than that in the incident beam of electromagnetic radiation, and in a propagation direction which is essentially undeviated and undisplaced from the incident beam of electromagnetic radiation, said compensator system further comprising third and forth Berek-type retarders which each have an optical axes essentially perpendicular to a surface thereof, each of which third and forth Berek-type retarders has a fast axis, said fast axes in said third and forth Berek-type retarders being oriented other than parallel to one another, said third and forth Berek-type retarders each presenting with first and second essentially parallel sides, and said third and forth Berek-type retarders being oriented, as viewed in side elevation, with first and second sides of one of said third and forth Berek-type retarders being oriented other than parallel to first and second sides of said forth Berek-type retarder; such that in use an incident beam of electromagnetic radiation exiting said second Berek-type retarder is caused to impinge upon said third Berek-type retarder on one side thereof, partially transmit therethrough then impinge upon said forth Berek-type retarder on one side thereof, and partially transmit therethrough such that a polarized beam of electromagnetic radiation passing through said first, second, third and forth Berek-type retarders emerges from the forth thereof in a polarized state with a phase angle between orthogonal components therein which is different than that in the

incident beam of electromagnetic radiation caused to impinge upon the first side of said first Berek-type retarder, and in a direction which is essentially undeviated and undisplaced from said incident beam of electromagnetic radiation; with a result being that retardation is entered between orthogonal components of said input electromagnetic beam of radiation.

18. A spectroscopic ellipsometer system as in Claim 5, in which the rotatable compensator comprises first, second, third and forth Berek-type retarders which each have an optical axes essentially perpendicular to a surface thereof, each of which first and second Berek-type retarders has a fast axis, said fast axes in said first and second Berek-type retarders being oriented essentially parallel to one another; said first and second Berek-type retarders each presenting with first and second essentially parallel sides, and said first and second Berek-type retarders being oriented, as viewed in side elevation, with first and second sides of one Berek-type retarder being oriented other than parallel to first and second sides of the other Berek-type retarder; such that in use an incident beam of electromagnetic radiation is caused to impinge upon one of said first and second Berek-type retarders on one side thereof, partially transmit therethrough then impinge upon the second Berek-type retarder, on one side thereof, and partially transmit therethrough such that a polarized beam of electromagnetic radiation passing through both of said first and second Berek-type retarders emerges from the second thereof in a polarized state with a phase angle between orthogonal components therein which is different than that in the incident beam of electromagnetic radiation, and in a propagation direction which is essentially undeviated and undisplaced from the incident beam of electromagnetic radiation; each of which third and forth Berek-type retarders has a fast axis, said fast axes in said third and forth Berek-type retarders being oriented essentially parallel to one another but other than parallel to

the fast axes of said first and second Berek-type retarders, said third and forth Berek-type retarders each presenting with first and second essentially parallel sides, and said third and forth Berek-type retarders being oriented, as viewed in side elevation, with first and second sides of one of said third and forth Berek-type retarders being oriented other than parallel to first and second sides of said forth Berek-type retarder; such that in use an incident beam of electromagnetic radiation exiting said second Berek-type retarder is caused to impinge upon said third Berek-type retarder on one side thereof, partially transmit therethrough then impinge upon said forth Berek-type retarder on one side thereof, and partially transmit therethrough such that a polarized beam of electromagnetic radiation passing through said first, second, third and forth Berek-type retarders emerges from the forth thereof in a polarized state with a phase angle between orthogonal components therein which is different than that in the incident beam of electromagnetic radiation caused to impinge upon the first side of said first Berek-type retarder, and in a direction which is essentially undeviated and undisplaced from said incident beam of electromagnetic radiation; with a result being that retardation is entered between orthogonal components of said input electromagnetic beam of radiation.

19. A spectroscopic ellipsometer system as in Claim 5, in which at least one selection is made from the group consisting of:

at least one of said polarizer and analyzer has its azimuthal angle set to a selection from the group consisting of:

essentially plus forty-five (45) degrees; and
essentially minus forty-five (45) degrees; and

in which said polarizer is set so as to select an "S" polarized electromagnetic beam component referenced to

the source of said electromagnetic beam.

20. A method of calibrating a spectroscopic ellipsometer system comprising the steps of:

a. providing a spectroscopic ellipsometer system comprising:

a source of polychromatic electromagnetic radiation;
a polarizer which remains fixed in position during data acquisition;
a stage for supporting a sample system;
an analyzer which remains fixed in position during data acquisition; and
a multi-element spectroscopic detector system;

said spectroscopic ellipsometer system further comprising at least one rotatable compensator means for discretely, sequentially, modifying a polarization state of a beam of electromagnetic radiation provided by said source of polychromatic electromagnetic radiation through a plurality of polarization states, said means for discretely, sequentially, modifying a polarization state of a beam of electromagnetic radiation provided by said source of polychromatic electromagnetic radiation through a plurality of polarization states being present at at least one location selected from the group consisting of:

between said polarizer and said stage for supporting a sample system; and

between said stage for supporting a sample system and said analyzer;

and positioned so that said beam of electromagnetic radiation

transmits therethrough in use;

said spectroscopic ellipsometer system being characterized by having, in a path of the electromagnetic beam between said a source of polychromatic electromagnetic radiation and said multi-element spectroscopic detector system, a beam chromatic shifting and directing means for use in reflectively directing a spectroscopic beam of electromagnetic radiation while de-emphasizing intensity in visual wavelengths and simultaneously emphasizing both IR and UV wavelength intensity

said method further comprising, in any functional order, the steps of:

b. for each of at least two ellipsometrically distinguished sample systems, obtaining at least one multi-dimensional data set(s) comprising intensity as a function of wavelength and a function of a plurality of discrete settings of said at least one means for discretely, sequentially, modifying a polarization state of a beam of electromagnetic radiation provided by said source of polychromatic electromagnetic radiation;

c. providing a mathematical model of the ellipsometer system, including provision for accounting for the settings of said at least one means for discretely, sequentially, modifying a polarization state of a beam of electromagnetic radiation provided by said source of polychromatic electromagnetic radiation utilized in step b; and

d. by simultaneous mathematical regression onto said data sets, evaluating parameters in said mathematical model, including polarization state changing aspects of each of said plurality of discrete settings of said at least one means for discretely, sequentially, modifying a polarization state of a beam of

electromagnetic radiation provided by said source of polychromatic electromagnetic radiation;

in which the step of providing a means for discretely, sequentially, modifying a polarization state of a beam of electromagnetic radiation provided by said source of polychromatic electromagnetic radiation through a plurality of polarization states, involves providing at least one compensator means that changes the phase angle between orthogonal components of said electromagnetic beam of radiation provided by said source of polychromatic electromagnetic radiation.

21. A method as in Claim 3 in which said beam chromatic shifting and directing means comprises a silicon substrate with between 500 and 1500 Angstroms of silicon dioxide substantially uniformly present on a reflective surface thereof.

22. A method as in Claim 5 in which said beam chromatic shifting and directing means comprises a silicon substrate with between 500 and 1500 Angstroms of silicon dioxide substantially uniformly present on a reflective surface thereof.

23. A method as in Claim 20 in which said beam chromatic shifting and directing means comprises a silicon substrate with between 500 and 1500 Angstroms of silicon dioxide substantially uniformly present on a reflective surface thereof.